PIER Energy-Related Environmental Research
Environmental Impacts of Energy Generation, Distribution and Use

Simplified Models for Particulate Dispersion in Buildings

Contract #: 500-02-004-WA MR-043-08
Contractor: University of California, San Diego,
Department of Mechanical and Aerospace Engineering
Contract Amount: $75,000
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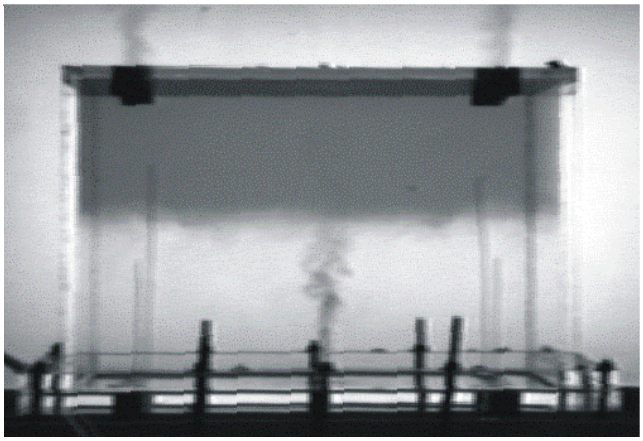
The Issue

Maintaining the internal temperature of buildings in a comfortable range accounts for a significant proportion of the total annual energy consumption of the United States (approximately 9% or 8.6 quadrillion BTU, costing about $90 billion per year).[1] As construction in relatively hot parts of the country is projected to increase markedly over the coming years, particularly in California, there is a pressing need to identify energy-efficient ways to cool buildings satisfactorily.



Small-scale Plexiglas room model showing natural displacement ventilation

Various low-energy systems such as displacement ventilation, underfloor air distribution, natural ventilation, and hybrid ventilation are under consideration. Most of these ventilation strategies rely on stratifying a space and extracting the warmest, most uncomfortable air, thus making these methods more efficient than conventional mixing ventilation. However, in order for these systems to be successful, it is also vital that they provide adequate levels of indoor air quality (IAQ) along with comfortable temperature and humidity. The introduction of outside air, either through filters or simply by opening a window, introduces outside pollutants. At the same time, internal pollutants are generated and need to be extracted from the building.

The success of alternative ventilation strategies depends on the ability to predict the internal environment and to assess the resulting IAQ and comfort, as well as to determine the potential energy savings. This project will expand capabilities in modeling contaminant distribution and transport within energy-efficient buildings, so that designers and engineers can have confidence that their buildings will perform appropriately.

[1] Energy Information Administration, 2000.

Project Description

Contaminants come in two forms—passive tracer types (gases and aerosols) and particulates (airborne solids). This project will investigate both forms using a combination of experimental and numerical modeling. The project team will develop analytical and numerical models aimed at capturing the behavior of passive tracer and particulate contaminants in stratified spaces.

The models will be validated on the basis of small-scale experiments in a Plexiglas room model. These small-scale studies will examine passive tracer gases and particulates, including effects such as settling velocities, deposition, resuspension, and coagulation.

Model predictions for particulate behavior will be further refined through complementary experiments in a full-scale room. Particulate contaminants of a known size distribution will be released and measured using laser-induced breakdown spectroscopy (LIBS). Results will be compared with the model predictions.

Finally, using all the results gathered from experiments and analysis, the project team will develop a simplified, semi-analytical model. The plan is that this model can be effectively and easily used as a design tool by building engineers in order to create low-energy ventilation schemes that also provide adequate levels of IAQ.

PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objectives:

- **Environmentally sound, safe, reliable, and affordable energy products.** The results of this research will help architects and engineers to specify energy-efficient cooling systems. By reducing demand for electricity, such cooling systems will reduce power plant emissions, increase system reliability during the summer peak demand hours, and lower cooling bills.
- **Improved public health.** A better understanding of the motion of contaminants and particulates within a building will help improve ventilation systems for better public health.

Final Report

PIER-EA staff intend to post the final report on the Energy Commission website in fall 2007 and will list the website link here.

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